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(54) **REDUCING CHANNEL-CHANGE TIME**

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- **DAVID GOMEZ-BARQUERO ET AL: "Application Layer FEC for Improved Mobile Reception of DVB-H Streaming Services", 2006 IEEE 64TH VEHICULAR TECHNOLOGY CONFERENCE : VTC 2006-FALL ; 25 - 28 SEPTEMBER 2006, MONTREAL, QUEBEC, CANADA, PISCATAWAY, NJ : IEEE OPERATIONS CENTER, 1 September 2006 (2006-09-01), pages 1-5, XP031051206, ISBN: 978-1-4244-0062-1**
- **"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs (Release 7)", 3GPP STANDARD; 3GPP TS 26.346, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. V7.1.0, 1 September 2006 (2006-09-01), pages 1-123, XP050370286,**

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Description

TECHNICAL FIELD

[0001] The present disclosure generally relates to systems and methods for processing communication signals. More particularly, the disclosure relates to reducing the time that it takes to change from one communication channel to another.

BACKGROUND

[0002] In the field of communication systems, many signals, such as audio and video signals, can be transmitted within different frequency channels. A receiving device is able to tune to a particular frequency allowing reception of the respective signals transmitted within that frequency. In systems involving the transmission of image data, for example, signals, such as those adhering to MPEG-2 standards, can be grouped into data packets, often referred to as a "group of pictures" (GOP). The structure of a GOP usually includes a header, a data section, and a trailer. The data section of the GOP structure typically includes a single "intra-frame" (I-frame) and a number of "forward predicted frames" (P-frames) and "bi-directionally predicted frames" (B-frames). An I-frame typically includes enough data to create a single frame by itself. P-frames are encoded to include difference values with respect to the data from one or more previous frames. B-frames are encoded to include difference values with respect to the data from one or more frames both before and after the B-frame.

[0003] When a receiver changes, or tunes to, a new channel, it is unlikely that the time instant of the channel change will correspond with the beginning of the GOP structure of the new channel. Hence, it is unlikely that the I-frame of the present GOP will be fully decoded. As a result, the receiver will typically be unable to decode the present GOP and will be required to wait for the next full GOP. Therefore, changing from one channel to another may take an undesirable length of time, which can be unacceptable to viewers. Given that the GOP is 15 frames and the frame rate is 30 frames per second, for example, the time between leaving one channel and displaying a frame of the new channel may be close to one second in a worst case scenario. Thus, a need exists to address these and other deficiencies and inadequacies of the present technologies to improve channel-change times.

[0004] Background art is: EP-A-1-684 450 which relates to a device and method for receiving a broadcast wave in which a plurality of services are multiplexed; WO 2006/061765 which relates to a data communication system and method; and US-B-6 480 541 which relates to a method and apparatus for providing scalable precompressed digital video with reduced quantization based artifacts.

[0005] The documents

DIGITAL FOUNTAIN: "Application layer reliability solutions for IP TV services", ETSI DRAFT; FGIPTV-ID-0097, EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE (ETSI), 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS; FRANCE, 21 July 2006 and

DAVID GOMEZ-BARQUERO ET AL: "Application Layer FEC for Improved Mobile Reception of DVB-H Streaming Services", 2006 IEEE 64TH VEHICULAR TECHNOLOGY CONFERENCE : VTC 2006-FALL ; 25 - 28 SEPTEMBER 2006, MONTREAL, QUEBEC, CANADA, PISCATAWAY, NJ : IEEE OPERATIONS CENTER disclose the use of FEC on application layer for either IPTV or DVB-H wherein the FEC transmission is delayed by the related processing time required.

[0006] In a first aspect, there is provided an apparatus according to claim 1 appended hereto. In a second aspect, there is provided a set-top box according to claim 8 appended hereto. In a third aspect, there is provided a method according to claim 13 appended hereto. Various other respective aspects and features are defined in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Many aspects of the embodiments disclosed herein can be better understood with reference to the following drawings. Like reference numerals designate corresponding parts throughout the several views.

FIG. 1 is a block diagram of an embodiment of a communication system.

FIG. 2 is a block diagram of an embodiment of the source shown in FIG. 1.

FIG. 3 is a diagram illustrating exemplary forward error correction for an array of data packets.

FIG. 4 is a block diagram of an embodiment of the receiver shown in FIG. 1.

FIG. 5 is a timing diagram illustrating an example of a GOP structure and a corresponding FEC.

FIG. 6 is a flow chart illustrating an embodiment of a method for processing image data and FEC during normal operation.

FIG. 7 is a flow chart illustrating an embodiment of a method for processing image data and FEC during a channel change event.

DETAILED DESCRIPTION

[0008] In typical communication systems, packets of data are transmitted between various devices. A data packet usually includes a header, data section, and a

trailer, wherein the header contains information that directs the packet to the correct receiver or receivers. The header may also include information that can be used to determine a number of packets being transmitted within a data stream. For example, a sequence number may be used for each packet to indicate the sequence of the packet within the stream. Because of any number of problems that may be encountered in a communication system, however, some packets of data may not reach their intended destinations. As a result of a receiver missing a number of packets and the information not reaching its intended destination, the integrity of the communication system may be compromised.

[0009] One solution for handling the problem of missed packets is to send "forward error correction" (FEC) code corresponding to the data. Typically, the FEC code is transmitted immediately after the transmission of data and is applied on a different multicast channel. If a device receiving the data and FEC determines that it has missed one or more packets, then the device uses the FEC code to attempt to correct the missing packets and fill in the gaps.

[0010] Not only can the FEC code be used for correcting errors, but the present disclosure also describes systems and methods for utilizing FEC in a communication system to reduce channel-change times. In this respect, the FEC code can function to correct errors as needed and to also fill in missing data due to a channel change when a new data stream is joined in the middle of a group of pictures (GOP).

[0011] FIG. 1 is a block diagram of an embodiment of a communication system 10. The communication system 10 may be any system or network for transferring data, such as, for example, an Internet protocol television (IP-TV) network for carrying digital video signals. The communication system 10 may transfer audio and video signals, encoded and compressed, for example, according to established standards, e.g. MPEG-2. When one or more data packets do not reach their intended destinations, the communication system 10 attempts to compensate for the missed packets. In this embodiment, the communication system 10 includes a number of communication devices 12 arranged in a multicast configuration. Regarding multicast schemes, certain communication devices 12 can create copies of the data and transmit the data to a group of destinations simultaneously over multiple communication links 14.

[0012] For the purpose of illustration, one communication device in FIG. 1 is labeled "source" 12_S and another communication device is labeled "receiver" 12_R. The source 12_S may be any component in the communication system 10 that transmits data downstream to another device. The source 12_S may be, among others, an edge device, multiplexer, encoder, etc. The source 12_S may be located in a head-end, central office, or other location, and/or may receive data from other sources. The source 12_S may also transmit, along with the data, a certain amount of FEC code to one or more intended recipients.

Data is transmitted on one multicast channel while the FEC code is typically transmitted on a different multicast channel.

[0013] The receiver 12_R may be any component in the communication system 10 that receives data from an upstream device. The terms "upstream" and "downstream" are used herein to refer to transfer of signals in one particular direction and are merely used for illustrative purposes. However, it should be recognized that data transfer might be directed in the opposite direction such that a downstream device transmits data to an upstream device. The receiver 12_R may be, among others, an end device, such as a computer, set-top box (STB), modem, etc. The receiver 12_R may be located in a customer premises, such as a home, office, school, etc., and/or may distribute data to other downstream receivers.

[0014] The communication link 14 between the source 12_S and receiver 12_R can be any suitable transmission path or channel and may contain transmission lines, wireless channels, fiber optic, or combinations of these or other types of communication links. Also, other communication devices 12 may be communicatively interposed between the source 12_S and receiver 12_R. In addition, the source and receiver may be located anywhere in the communication system 10 and separated by any distance.

[0015] Typically, data is transmitted to a group of receivers in a first multicast group. A certain amount of FEC code, transmitted with the data, is sent in a second multicast group. As described in more detail below, the timing of the FEC code with respect to the data is managed in order to reduce the channel-change time. Normally, the receivers configured to tune to the first multicast group are also configured to tune to the second multicast group to receive both data and FEC code. The particular use of multicast channels may be dependent upon the last-mile technology of the communication system 10.

[0016] In the present disclosure, the source 12_S and receiver 12_R, and portions thereof, can be implemented in hardware, software, firmware, or a combination thereof. If the source 12_S and receiver 12_R contain software or firmware for performing the disclosed functions, the software or firmware may be stored in a memory and executed by a suitable instruction execution system. If implemented in hardware, the source 12_S and receiver 12_R can be implemented, for example, with discrete logic circuitry, an application specific integrated circuit (ASIC), a programmable gate array (PGA), a field programmable gate array (FPGA), or any suitable combination of logic components.

[0017] FIG. 2 is a block diagram of an embodiment, illustrated in a simplified form, of the source 12_S shown in FIG. 1. The source 12_S may be configured to operate in conjunction with the receiver 12_R as described below with respect to FIG. 4 or with any suitable receiver having corresponding circuitry and/or functionality for receiving data and FEC code. The source 12_S may be a multiplexer, digital subscriber line access multiplexer (DSLAM),

decoder, router, digital content manager (DCM), video acceleration module (VAM), edge device, or other communication device that transfers data to another location or component. As an example, the source 12_S may be located at a head-end facility, central office, node, or at other locations in the communication system 10.

[0018] In this embodiment, the source 12_S includes, among other things, a processor 20, a buffer 22, and a driver 24. Normally, the buffer 22 receives streams of data packets from another source or group of sources. The driver 24 may include any suitable component or combination of components for outputting, driving, or transmitting signals to one or more destination devices. The driver 24 may be configured to communicate with one receiver, or, in the case of a multicast system, with multiple receivers.

[0019] The processor 20 is configured to access the packets from the buffer 22 and calculate FEC code designed to overcome a certain amount of missed data. It should be understood, however, that the processor 20 may use any suitable algorithms for creating the FEC. The processor 20 stores the calculated FEC code in the buffer 22. Also, the processor instructs the driver 24 to transmit the data packets and FEC from the buffer 22 along the communication link 14 to the receiver 12_R or receivers. The driver 24 is configured to transmit the FEC in a time-delayed manner with respect to the corresponding data. In some embodiments, the FEC is transmitted with an offset in time of about half of a GOP length. In this way, the FEC, in addition to correcting error, can also be used to reduce the time that it takes to change from one channel to another, as is explained in more detail below. In some embodiments, however, the FEC may be interleaved with the data or appended to the data and transmitted on the same multicast channel. However, other transmission techniques may be used as well. Also, the relationship between the time of transmission of the data and the time of transmission of the FEC may be variable and may depend on other factors as described herein.

[0020] The processor 20 is also configured to encode the data in a GOP structure, which is established for each particular channel. The GOP structure includes a header, the GOP data, and a trailer, as depicted in FIG. 5. The GOP data may include any number of frames. A first frame is referred to as an intra-frame, or I-frame, which maintains much of its original form without significant compression. The GOP data also includes forward prediction frames (P-frames) and bi-directional prediction frames (B-frames). P-frames are encoded based on the difference values of previous frames and B-frames are encoded based on the difference values of previous and/or later frames. The algorithms for encoding and compressing frames to achieve P-frames and B-frames are more complex than those for I-frames, but the resulting bandwidth of P-frames and B-frames is less than the bandwidth of the I-frames, thereby allowing for the transmission of an entire GOP structure that can be used to

produce high quality pictures.

[0021] The processor 20 also encodes the header of the GOP structure, which includes information that defines a relationship between the GOP data and the FEC.

The header is also encoded with synchronization information that describes how the GOP is protected. For example, the synchronization information may include information related to the delay between a particular frame of the GOP and its associated FEC data. Based on this information, the receiver 12_R can align the FEC with the GOP to fill in any gaps where the GOP data is missed due to errors. In the additional occurrence of a channel change, the FEC is used to fill in portions of the GOP that were missed due to joining the stream in the middle of the GOP. The GOP structure also includes header and trailer information that defines the boundaries of the data stream packets.

[0022] In particular, the source 12_S receives or acquires data in any suitable manner and processes the data to determine FEC code. The FEC code may be in any suitable form created using any suitable encoding algorithm or combination of algorithms, such as PRO-MPEG, Raptor, or others. For example, the data packets may be laid out in an array having R rows and C columns, as depicted in FIG. 3. In a simple PRO-MPEG algorithm, for example, the FEC may be calculated by determining an exclusive-OR (XOR) of the packets in each row to achieve a number R of row XORs and an XOR of the packets in each column to achieve a number C of column XORs. In this example, the total number of FEC portions is R+C, which is sufficient, in some scenarios, to handle up to R+C missed packets, which is an extremely deep FEC. If packet (1, 2) were dropped, for example, the dropped packet can be restored using packets (1, 0), (1, 1), (1, 3) through (1, C), and XOR ((1, 0) - (1, C)). Instead of using the row XOR and other packets of the row, packet (1, 2) can also be restored using the packets of the same column and the column XOR.

[0023] FIG. 4 is a block diagram of an embodiment, illustrated in a simplified form, of the receiver 12_R shown in FIG. 1. In some embodiments, for example, the receiver 12_R may operate in conjunction with the source 12_S shown in FIG. 2 or with another respective source having related functionality for transmitting data and corresponding FEC that is offset in time to reduce channel-change times. The receiver 12_R may be configured as or incorporated within, among other devices, a set-top box, computer, modem, VAM, etc. In this embodiment, the receiver 12_R includes, among other things, a processor 30, a buffer 32, and an input device 34.

[0024] The input device 34 may include one or more tuners for tuning to a particular frequency channel, which may correspond to a "television channel", for example. When the FEC is transmitted on a multicast channel that is different from the channel of the corresponding data, the input device 34 includes at least one tuner for each respective channel. In some embodiments, the GOP and FEC are transmitted on the same channel and the input

device 34 may include a single tuner in this case. When the input device 34 receives the incoming data packets and FEC, the data and FEC can be stored in the buffer 32.

[0025] In normal operation, the processor 30 accesses the data and FEC from the buffer 32 to determine the condition of the received data. By analyzing the header, or particularly the sequence numbers in the headers of the data packets, to determine the packets that were transmitted, the processor 30 can determine if any packets were not received. If the FEC is sufficient to recover the missed packet or packets, then the transmission is considered a success. In this case, the data packets are corrected or restored, if necessary, and transmitted to the next communication device 12, if any, in the communication system 10. Regarding embodiments in which the receiver 12_R is a set-top box or other similarly functioning device, the processor 30 decodes the frames of the GOP and stores frame data in a frame buffer (not shown) of the buffer 32. The frame data can then be read out to a television set (not shown) or other display device at designated time intervals, e.g. 30 frames per second.

[0026] For purposes of illustration, the GOP as defined in the embodiments described herein includes 15 frames. However, it should be understood that the GOP may be set with any number of frames. For a 15-frame GOP used in a system that displays 30 frames per second, the GOP is decoded and displayed within about 500ms, or about half a second. When a channel change occurs, the time of the change may be any time during the 500ms GOP band. However, since the frames cannot usually be decoded without the I-frame, if all or part of the I-frame is missed, then the receiver of the prior art is forced to wait until the next GOP is received. In this respect, the channel change may take up to 900ms, which may be undesirable for most viewers.

[0027] To overcome this problem, the present disclosure provides a way to utilize the FEC to fill in the data of the intermediate GOP tuned to in midstream. When the FEC lags the GOP by about 250ms, then 500ms worth of data can read in about 250ms, where about half of the data or more is decoded from the GOP itself while up to about half of the data is decoded from the FEC. Since the FEC can be decoded in about 10ms, the FEC may be shifted forward in time to compensate for the decoding time. In this way, the FEC is effectively offset by about half the bandwidth of the GOP. The processor 30 decodes the GOP and FEC simultaneously during a channel change and can fill the buffer 32 in about 250ms or less. Using this process, the present disclosure can provide channel-change times that, even in the worst case, may be up to a half second or more faster than the worst case of the prior art. This results in a more responsive channel-changing process, which is likely to be more desirable for a viewer.

[0028] The data size, or "quanta", of the GOP may be variable, since it is based on scene complexity. The GOP data may be transmitted using a constant bit rate (CBR) or a variable bit rate (VBR). In a CBR stream, the trans-

mission time, or "protection period", taken to send the quanta is directly proportional to the quanta. In a VBR stream, the protection period is variably proportional to the quanta. The time offset of the FEC with respect to the GOP is dependent on the protection period, which is dependent on the quanta. The FEC may be encoded such that it is capable of being used during a channel-change event that just misses the I-frame. In this disclosure, "just missing" the I-frame may be a time of channel change that occurs within about 0-100ms after the end of the I-frame.

[0029] The processor 30 is also configured to determine whether to decode using the GOP, FEC, or both, during a channel change event. Also, the processor 30 also determines what proportion of each to decode. The processor 30 may include or access software for determining which code or portions of code to use. By receiving a quanta worth of data, the processor 30 can generate the GOP frames and fill the buffer 32 in about 250ms.

[0030] In addition, while processing the GOP frames of the initially-tuned-to intermediate GOP, the processor 30 is further capable of determining where the channel change occurred with respect to the entire length of GOP. In this respect, only the last frames of the GOP are stored in the buffer 32, as subsequently displayed, wherein the number of the last frames depends on where the channel change occurred. Therefore, when the first whole GOP structure is received and decoded without the assistance of the FEC, provided that no error correction is needed, then the I-frame of the next GOP structure is displayed immediately after the last P-frame or B-frame of the previous GOP. Otherwise, a noticeably distracting skip in time may occur after a channel change.

[0031] The method of processing the GOP and FEC during a channel change event may comprise an ordered listing of executable instructions for implementing logical functions as discussed above. The instructions and programs for executing these functions can be embodied in any computer-readable medium for use in or by an instruction execution system, apparatus, or device. In the context of this document, a "computer-readable medium" can be any medium that can contain, store, communicate, propagate, or transport the program for use by the instruction execution system, apparatus, or device. The scope of the present disclosure is intended to include the functionality of the disclosed embodiments configured with logic in hardware and/or software mediums.

[0032] FIG. 5 is a chart illustrating exemplary timing characteristics of GOP structures and FEC. Each GOP structure includes a header, GOP data, and a trailer. In this illustration, GOP₁ is shown in a stream with other GOP structures. Each GOP structure may be about 500ms, but may be variable based on the complexity of the scenes. For example, when the frames include simple images and do not change significantly from frame to frame, the coding of the GOP can be simple. However, when the frames include a greater amount of image complexity and/or a greater amount of movement or scene

changing, for example, then the coding of the GOP can be more complex.

[0033] The GOP data in this example includes 15 frames having a pattern of I-frames, B-frames, and P-frames of IBB_PBB_PBB_PBB_PBB. This pattern or other patterns may be used and are usually established on a per-channel basis. When a channel change occurs, the processor 30 decodes either the header of the GOP or the header information decoded from the lagging FEC. From the information decoded from the header, the processor 30 can determine the number of frames in the new channel's GOP and its pattern of frames. From the header, the processor 30 can also determine the relationship between the GOP and FEC, such as lag time; etc.

[0034] Since the quanta of the GOP may be variable, the header and trailer may be adjusted as needed to fill the 500ms timeframe. Also, the bit rate may be changed as needed to maintain a constant stream. Alternatively, the GOP structures may slightly overlap if necessary. In this case, some data may be dropped.

[0035] As an example, FIG. 5 also illustrates 15 time periods spanning 500ms and representing an example of the frame display times. For example, when the I-frame is processed, the frame can be displayed in time period "I". The two subsequent B-frames can be displayed in time periods B₁ and B₂. The next frame (a P-frame) can be displayed in time period P₁, and so on. Once the I-frame is completely received, the processing for this frame can begin. The processing time may be different from the time shown and may be faster or slower than the illustrated timing.

[0036] It can be appreciated from observing the timing characteristics of the example illustration of FIG. 5 that a channel change may occur during the reception of the I-frame. In this case, the prior art may be forced to wait until the next 500ms interval before a new GOP is received. In this disclosure, however, portions of the I-frame may be missed when encoding the GOP, but the missed data can be picked up and decoded using the time-delayed FEC, which includes enough data to recreate the GOP structure. For example, FEC₁ represents the FEC that corresponds to GOP₁ and lags the GOP by about 250ms. In some embodiments, the FEC may be placed to account for just missing the I-frame. In some instances, the I-frame of the GOP may be received in full, but other times the I-frame may be missed partially or totally. When the I-frame is missed partially, the portion of the FEC related to the missed part of the I-frame can be used to augment the I-frame to enable recreation of the I-frame. In the case of the I-frame being totally missed, the FEC related to the I-frame can be used to completely recreate the I-frame. The FEC may also be used to recreate, partially or totally, the P-frames and B-frames as needed.

[0037] In addition, the FEC is encoded to include substantially the same timing characteristics as the GOP and is substantially similar to the GOP with respect to quanta, protection period, bit rate, etc. When the FEC is substan-

tially equal in bandwidth to the GOP, the lag time may be about 250ms. To account for the extra time to process the FEC, an approximate shift may be made to the FEC phase. In this respect, the lag time is decreased slightly.

The timing of the FEC may also depend on the protection period of the GOP. By offsetting the FEC by an ideal lag time with respect to the GOP, the time to fill the buffer 32 with 500ms of frames (15 frames) may take as little as 250ms.

[0038] With respect to FIGS. 6 and 7, the functional operations of the communication system 10 is described. Although particular references may be made to the physical elements illustrated in FIGS. 1, 2, and 4, it should be understood that the following processes, steps, functions, or operations may be performed by any suitable components as will be understood by one of reasonable skill in the art.

[0039] FIG. 6 is a flow chart illustrating an embodiment of a method 40 for processing data and FEC during normal operation. The method 40 includes receiving data and FEC, as shown in block 42. The data, for example, may be audio and/or image data and may be encoded and/or compressed according to audio/video standards, such as the Moving Picture Experts Group (MPEG) standards. The data may be arranged in a GOP structure.

[0040] In block 44, the data is decoded. In decision block 46, it is determined whether or not any errors occur in the decoded data. If it is determined that there are no errors, the flow chart proceeds to block 52. If errors do exist, then the process moves to block 48, where the FEC is decoded. In block 50, the FEC is used to correct the detected errors, if possible. In block 52, the decoded data and/or restored data (from the FEC-corrected data) are stored as image data in a buffer. For example, the buffer may be a memory device having a frame buffer for storing frames. The buffer may store the images in a frame format or field format. In block 54, the frames are retrieved from the buffer and transmitted to a display device, e.g. television set, for display.

[0041] FIG. 7 is a flow chart illustrating an embodiment of a method 60 for processing data and FEC during a channel change event. For example, the method 60 may be carried out by a device that receives image data. More particular, the receiving device may be a set-top box or other suitable processing device for feeding image signals to a display device, such as a television set. The method 60 includes receiving an indication that a channel change has been requested, as indicted by block 62. For example, a viewer may request that a new channel be displayed by any number of entry mechanisms, such as pressing control buttons on the set-top box, pressing up or down buttons on a remote control, pressing number buttons on a remote control, etc.

[0042] In response to the channel-change request, the method proceeds to block 64. In this block, the receiver tunes to the new channel to receive the data. The receiver also receives corresponding FEC code. The FEC code may be transmitted on the same multicast channel as

the regular data or may be transmitted on a different channel. If the FEC code is transmitted on a different channel, the receiver tunes to both the channel for the data and the FEC channel.

[0043] In block 66, the data and FEC is decoded. For example, the data and FEC may be decoded simultaneously to decrease the overall channel-change time. In block 68, the FEC is used to recreate frames of the new channel that were missed. In this respect, the FEC is preferably offset in time to allow receiving portions of the data that were transmitted (and missed) before the channel-change request. In this case, the FEC is used to help recreate earlier frames of a GOP to be used for processing the real-time frames. Since the FEC is designed to correct errors, it should be noted that during a channel change, the FEC can be used to fill in data that is missed on account of joining the data stream in the middle of the GOP.

[0044] As a result of the FEC augmenting the regular data, the receiving (block 64), decoding (block 66), and frame constructing (block 68) can be completed in about half the time that a full GOP can usually be created. In block 70, the images recreated with the help of the FEC are stored in a buffer. The buffer may be designed to be able to store the last number of frames of the particular GOP that was tuned to midstream when the channel change is initially requested. In block 72, the images are read out of the buffer and transmitted to a display device, which displays the images.

[0045] The flow charts illustrated in FIGS. 6 and 7 show the architecture, functionality, and operation of possible implementations of the communication system. In this regard, each block may represent a module, segment, or portion of code, which may be configured in software. Each block comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that in some alternative embodiments, the functions noted in the blocks may occur out of the order shown or described or may not occur at all. In addition, two or more blocks may be executed substantially concurrently, depending upon the functionality involved. Alternative embodiments are considered to be included within the scope of the present disclosure as would be understood by those reasonably skilled in the art.

[0046] Conditional language, such as "can," "could," "might," or "may," among others, is generally intended to convey, unless specifically stated otherwise, or otherwise understood within the context, that certain embodiments include, while other embodiments do not include, certain features, elements, and/or steps. Thus, such conditional language is not generally intended to imply that features, elements and/or steps are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without user input or prompting, whether these features, elements and/or steps are included or are to be performed in any particular embodiment.

[0047] It should be emphasized that the above-described embodiments are merely examples of possible implementations. Many variations and modifications may be made to the above-described embodiments without departing from the principles of the present disclosure. All such modifications and variations are intended to be included herein within the scope of this disclosure and protected by the following claims.

Claims

1. An apparatus (12s) for processing image data, the apparatus (12s) comprising:
 - a buffer (22) configured to receive image signals from one or more sources;
 - a processor (20) configured to encode the image signals to create a group of pictures (GOP) structure, wherein the processor is further configured to encode the image signals to create forward error correction (FEC) code capable of correcting errors in the GOP structure; and
 - a driver (24) configured to transmit the GOP structure and the FEC code, wherein the FEC code lags the GOP structure by a lag time selected in dependence on a transmission time taken to send the GOP structure, wherein the transmission time is dependent on the data size of the GOP structure, so as to allow a device receiving the GOP structure and the FEC code to utilize both the GOP structure and the FEC code during a channel-change event to recreate portions of data of the GOP structure that were missed due to the channel-change event occurring during the transmission of the GOP structure, thereby decreasing channel-change time.
2. The apparatus (12s) of claim 1, wherein the apparatus (12s) is embodied within a head-end facility.
3. The apparatus (12s) of claim 1, wherein the processor is configured to encode a header of the GOP structure to include information pertaining to the relationship between the GOP structure and the FEC code.
4. The apparatus (12s) of claim 1, wherein the GOP structure includes between 12 and 30 frames.
5. The apparatus (12s) of claim 1, wherein the lag time is substantially equal to one-half of the transmission time of the GOP structure.
6. The apparatus (12s) of claim 1, wherein the lag time is further dependent on a time to process the FEC code.

7. A set-top box (12r) adapted to perform a channel change, comprising:

means for receiving a channel-change indication indicating a change from a first channel to a second channel;
 an input device (34) for receiving a portion of a group of pictures (GOP) structure being transmitted on the second channel and forward error correction (FEC) code corresponding to the GOP structure, wherein the FEC code is received offset from the corresponding GOP structure by a time delay that is dependent on a transmission time taken to send the GOP structure, wherein the transmission time is dependent on the data size of the GOP structure; and
 a processor (30) configured to decode the GOP structure and the FEC code during the channel-change, the processor arranged to utilize the FEC code to recreate portions of data of the GOP structure that were missed due to the channel-change indication occurring during the transmission of the GOP structure.

8. The set-top box (12r) of claim 7, further comprising a buffer (32) for storing frames to be displayed on a display device.

9. The set-top box (12r) of claim 7, wherein the processor (30) performs an algorithm to determine which portions of the GOP structure and the FEC code to use to calculate an I-frame of the GOP structure tuned to during the channel-change.

10. A method for executing a change from a first communication channel to a second communication channel, the method comprising:

receiving (62) a channel-change indication indicating a change from the first channel to the second channel;
 obtaining (64) data and forward error correction (FEC) code that corresponds to the data, wherein the data and FEC code are related to the second channel, the data including a portion of data within a group of pictures (GOP) structure being transmitted on the second channel, wherein the FEC code is received offset from the corresponding GOP structure by a time delay that is dependent on a transmission time taken to send the GOP structure, wherein the transmission time is dependent on the data size of the GOP structure; and
 utilizing (68) the FEC code to recreate portions of data of the GOP structure that were missed due to the channel-change indication occurring during the transmission of the GOP structure.

11. The method of claim 10, wherein utilizing (68) the FEC code to recreate portions of the data further comprises recreating frames for display on a display device.

12. The method of claim 11, further comprising: storing (70) the frames in a frame buffer.

13. The method of claim 10, wherein obtaining the FEC code includes obtaining the FEC code at a time that lags the time that the data is obtained by substantially one-half of the period of the GOP structure.

14. The method of claim 10, further comprising:

determining whether or not errors exist in the GOP structure; and
 utilizing the FEC code to correct errors in the GOP structure when it is determined that errors exist.

Patentansprüche

1. Vorrichtung (12s) zum Verarbeiten von Bilddaten, wobei die Vorrichtung (12s) Folgendes umfasst:

einen Puffer (22), der dafür konfiguriert ist, Bildsignale von einer oder mehreren Quellen zu empfangen;
 einen Prozessor (20), der dafür konfiguriert ist, die Bildsignale zu kodieren, um eine Bildgruppenstruktur (GOP - Group of Pictures) zu erstellen, wobei der Prozessor ferner dafür konfiguriert ist, die Bildsignale zu kodieren, um einen Vorwärtsfehlerkorrekturcode (FEC - Forward Error Correction) zu erstellen, der Fehler in der GOP-Struktur korrigieren kann; und
 einen Treiber (24), der dafür konfiguriert ist, die GOP-Struktur und den FEC-Code zu übertragen, wobei der FEC-Code hinter der GOP-Struktur um eine Verzögerungszeit zurückliegt, die in Abhängigkeit von einer Sendezeit ausgewählt wird, die zum Senden der GOP-Struktur genommen wird, wobei die Sendezeit von der Datengröße der GOP-Struktur abhängig ist, um einer Vorrichtung, die die GOP-Struktur und den FEC-Code empfängt, zu ermöglichen, sowohl die GOP-Struktur als auch den FEC-Code bei einem Kanalwechselereignis zu nutzen, um Teile der Daten der GOP-Struktur erneut zu erzeugen, die aufgrund des Kanalwechselereignisses verpasst wurden, das während der Übertragung der GOP-Struktur auftrat, wodurch die Zeit des Kanalwechsels verringert wird.

2. Vorrichtung (12s) nach Anspruch 1, wobei die Vorrichtung (12s) in einer Kopfstelleneinrichtung ver-

wirklich ist.

3. Vorrichtung (12s) nach Anspruch 1, wobei der Prozessor dafür konfiguriert ist, einen Kopfdatensatz der GOP-Struktur so zu kodieren, dass er Informationen in Bezug auf das Verhältnis zwischen der GOP-Struktur und dem FEC-Code umfasst. 5
4. Vorrichtung (12s) nach Anspruch 1, wobei die GOP-Struktur zwischen 12 und 30 Rahmen umfasst. 10
5. Vorrichtung (12s) nach Anspruch 1, wobei die Verzögerungszeit im Wesentlichen der Hälfte der Sendezeit der GOP-Struktur entspricht. 15
6. Vorrichtung (12s) nach Anspruch 1, wobei die Verzögerungszeit ferner von einer Zeit zur Verarbeitung des FEC-Codes abhängig ist. 20
7. Digitalempfänger (12r), der dafür ausgelegt ist, einen Kanalwechsel durchzuführen und Folgendes umfasst: 25

Mittel zum Empfangen einer Kanalwechselangabe, die einen Wechsel von einem ersten Kanal zu einem zweiten Kanal angibt; eine Eingabevorrichtung (34) für den Empfang von Folgendem: eines Teils einer Bildgruppenstruktur (GOP), die auf dem zweiten Kanal übertragen wird, und eines Vorwärtsfehlerkorrekturcodes (FEC), der der GOP-Struktur entspricht, wobei der FEC-Code von der entsprechenden GOP-Struktur um eine Zeitverzögerung versetzt empfangen wird, die von einer Sendezeit abhängt, die zum Senden der GOP-Struktur genommen wird, wobei die Sendezeit von der Datengröße der GOP-Struktur abhängig ist; und einen Prozessor (30), der dafür konfiguriert ist, die GOP-Struktur und den FEC-Code während des Kanalwechsels zu decodieren, wobei der Prozessor dafür ausgelegt ist, den FEC-Code zu verwenden, um Teile der Daten der GOP-Struktur erneut zu erzeugen, die aufgrund der Kanalwechselangabe verpasst wurden, die während der Übertragung der GOP-Struktur auftrat. 30 35 40 45
8. Digitalempfänger (12r) nach Anspruch 7, der ferner einen Puffer (32) zum Speichern von Rahmen umfasst, die auf einer Anzeigevorrichtung angezeigt werden sollen. 50
9. Digitalempfänger (12r) nach Anspruch 7, wobei der Prozessor (30) einen Algorithmus ausführt, um zu bestimmen, welche Teile der GOP-Struktur und des FEC-Codes zu verwenden sind, um einen I-Rahmen der GOP-Struktur zu berechnen, auf die während des Kanalwechsels abgestimmt ist. 55

10. Verfahren zum Ausführen eines Wechsels von einem ersten Kommunikationskanal zu einem zweiten Kommunikationskanal, wobei das Verfahren Folgendes umfasst:

Empfangen (62) einer Kanalwechselangabe, die einen Wechsel von dem ersten Kanal zu dem zweiten Kanal angibt;
 Erhalten (64) von Daten und eines Vorwärtsfehlerkorrekturcodes (FEC), der den Daten entspricht, wobei die Daten und der FEC-Code mit dem zweiten Kanal in Beziehung stehen, wobei die Daten einen Teil der Daten innerhalb einer Bildgruppenstruktur (GOP) umfassen, die auf dem zweiten Kanal übertragen wird, wobei der FEC-Code von der entsprechenden GOP-Struktur um eine Zeitverzögerung versetzt empfangen wird, die von einer Sendezeit abhängt, die zum Senden der GOP-Struktur genommen wird, wobei die Sendezeit von der Datengröße der GOP-Struktur abhängig ist; und
 Verwenden (68) des FEC-Codes, um Teile der Daten der GOP-Struktur erneut zu erzeugen, die aufgrund der Kanalwechselangabe verpasst wurden, die während der Übertragung der GOP-Struktur auftrat.

11. Verfahren nach Anspruch 10, wobei die Verwendung (68) des FEC-Codes zur erneuten Erzeugung von Teilen der Daten ferner das erneute Erzeugen von Rahmen für die Anzeige auf einer Anzeigevorrichtung umfasst.
12. Verfahren nach Anspruch 11, das ferner Folgendes umfasst: Speichern (70) der Rahmen in einem Rahmenpuffer.
13. Verfahren nach Anspruch 10, wobei das Erhalten des FEC-Codes Folgendes umfasst: Erhalten des FEC-Codes zu einem Zeitpunkt, der im Wesentlichen um die Hälfte der Zeitdauer der GOP-Struktur hinter dem Zeitpunkt zurückliegt, zu dem die Daten erhalten wurden.
14. Verfahren nach Anspruch 10, das ferner Folgendes umfasst:

Bestimmen, ob Fehler in der GOP-Struktur vorhanden sind; und
 Verwenden des FEC-Codes, um Fehler in der GOP-Struktur zu korrigieren, wenn bestimmt wird, dass Fehler vorhanden sind.

Revendications

1. Appareil (12s) pour traiter des données d'images, l'appareil (12s) comprenant :

- une mémoire-tampon (22) configurée de façon à recevoir des signaux d'images en provenance d'une ou de plusieurs sources ;
 un processeur (20) configuré de façon à coder les signaux d'images afin de créer une structure de groupe d'images (GOP), le processeur étant configuré en outre de façon à coder les signaux d'images afin de créer un code de correction d'erreurs sans voie de retour (FEC) capable de corriger des erreurs dans la structure GOP ; et un pilote (24) configuré de façon à transmettre la structure GOP et le code FEC, cas dans lequel le code FEC est en retard par rapport à la structure GOP suivant un intervalle de temporisation sélectionné en dépendance d'une durée de transmission qu'il faut pour envoyer la structure GOP, cas dans lequel la durée de transmission est subordonnée à la taille des données de la structure GOP, de sorte à permettre à un dispositif recevant la structure GOP et le code FEC d'utiliser à la fois la structure GOP et le code FEC au cours d'un événement de changement de canal afin de recréer des portions de données de la structure GOP qui ont été manquées en raison du fait que l'événement de changement de canal est survenu au cours de la transmission de la structure GOP, faisant ainsi diminuer le temps de changement de canal.
2. Appareil (12s) selon la revendication 1, l'appareil (12s) étant concrétisé au sein d'une installation de tête de réseau.
 3. Appareil (12s) selon la revendication 1, le processeur étant configuré de façon à coder un en-tête de la structure GOP afin d'inclure des informations relatives à la corrélation entre la structure GOP et le code FEC.
 4. Appareil (12s) selon la revendication 1, la structure GOP incluant entre 12 et 30 trames.
 5. Appareil (12s) selon la revendication 1, l'intervalle de temporisation étant sensiblement égal à une moitié de la durée de transmission de la structure GOP.
 6. Appareil (12s) selon la revendication 1, l'intervalle de temporisation étant subordonné en outre à une durée requise pour traiter le code FEC.
 7. Boîtier décodeur (12r) conçu pour effectuer un changement de canal, comprenant :
 - des moyens pour recevoir une indication de changement de canal indiquant un changement à partir d'un premier canal vers un deuxième canal ;
 - un dispositif d'entrée (34) pour recevoir une portion d'une structure de groupe d'images (GOP) en train d'être transmise sur le deuxième canal et un code de correction d'erreurs sans voie de retour (FEC) correspondant à la structure GOP, cas dans lequel le code FEC est reçu en décalage par rapport à la structure GOP correspondante suivant un intervalle de temporisation qui est subordonné à une durée de transmission qu'il faut pour envoyer la structure GOP, cas dans lequel la durée de transmission est subordonnée à la taille des données de la structure GOP ; et
 - un processeur (30) configuré de façon à décoder la structure GOP et le code FEC au cours du changement de canal, le processeur étant agencé de façon à utiliser le code FEC pour recréer des portions de données de la structure GOP qui ont été manquées en raison du fait que l'indication de changement de canal est survenue au cours de la transmission de la structure GOP.
 8. Boîtier décodeur (12r) selon la revendication 7, comprenant en outre une mémoire-tampon (32) pour stocker des trames destinées à être affichées sur un dispositif afficheur.
 9. Boîtier décodeur (12r) selon la revendication 7, le processeur (30) effectuant un algorithme afin de déterminer quelles portions de la structure GOP et du code FEC sont à utiliser pour calculer une trame I de la structure GOP à laquelle elle a été accordée au cours du changement de canal.
 10. Procédé pour exécuter un changement à partir d'un premier canal de communication vers un deuxième canal de communication, le procédé comprenant les opérations consistant à :
 - recevoir (62) une indication de changement de canal indiquant un changement à partir du premier canal vers le deuxième canal ;
 - obtenir (64) des données et un code de correction d'erreurs sans voie de retour (FEC) qui correspond aux données, cas dans lequel les données et le code FEC sont liées au deuxième canal, les données incluant une portion de données au sein d'une structure de groupe d'images (GOP) en train d'être transmises sur le deuxième canal, cas dans lequel le code FEC est reçu en décalage par rapport à la structure GOP correspondante suivant un intervalle de temporisation qui est subordonné à une durée de transmission qu'il faut pour envoyer la structure GOP, cas dans lequel la durée de transmission est subordonnée à la taille des données de la structure GOP ; et
 - utiliser (68) le code FEC pour recréer des portions de données de la structure GOP qui ont

été manquées en raison du fait que l'indication de changement de canal est survenue au cours de la transmission de la structure GOP.

11. Procédé selon la revendication 10, l'utilisation (68) du code FEC pour recréer des portions des données comprenant en outre l'opération consistant à recréer des trames en vue d'un affichage sur un dispositif afficheur. 5
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12. Procédé selon la revendication 11, comprenant en outre l'opération consistant à : stocker (70) les trames dans une mémoire-tampon de trames.
13. Procédé selon la revendication 10, l'obtention du code FEC comprenant l'opération consistant à obtenir le code FEC à un moment qui est en retard par rapport au moment auquel les données sont obtenues, suivant sensiblement une moitié de la période de la structure GOP. 15
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14. Procédé selon la revendication 10, comprenant en outre les opérations consistant à :

déterminer si oui, ou non, des erreurs existent 25
dans la structure GOP ; et
utiliser le code FEC pour corriger des erreurs
dans la structure GOP quand il a été déterminé
que des erreurs existent.
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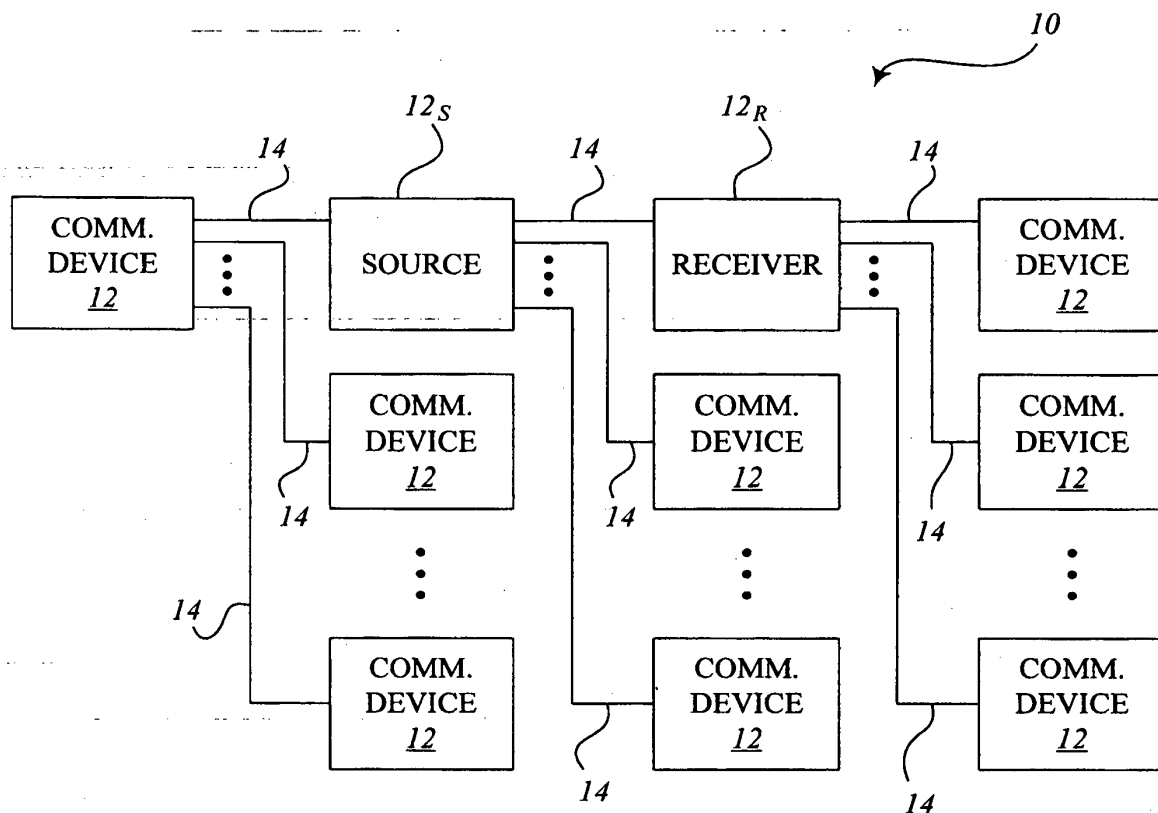


FIG. 1

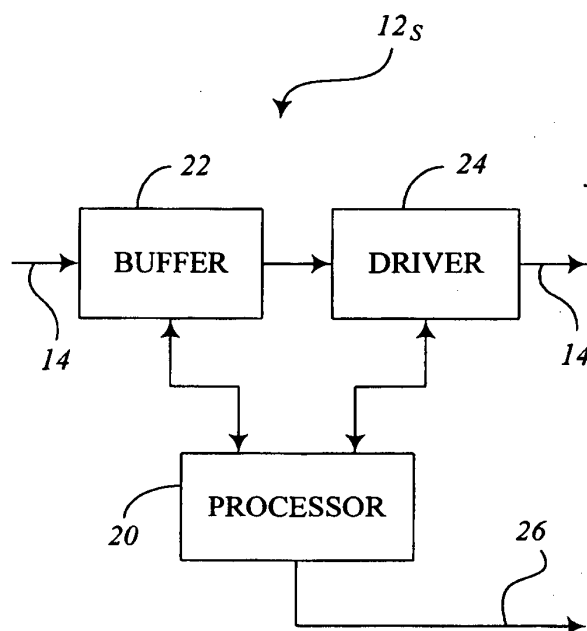
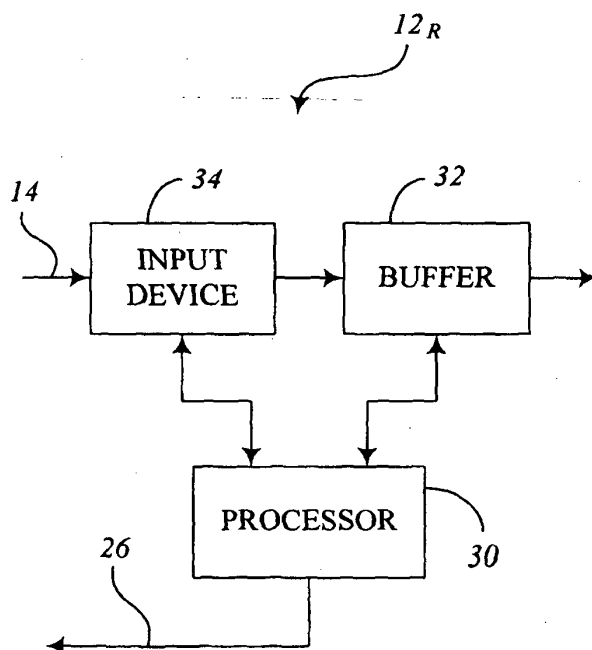
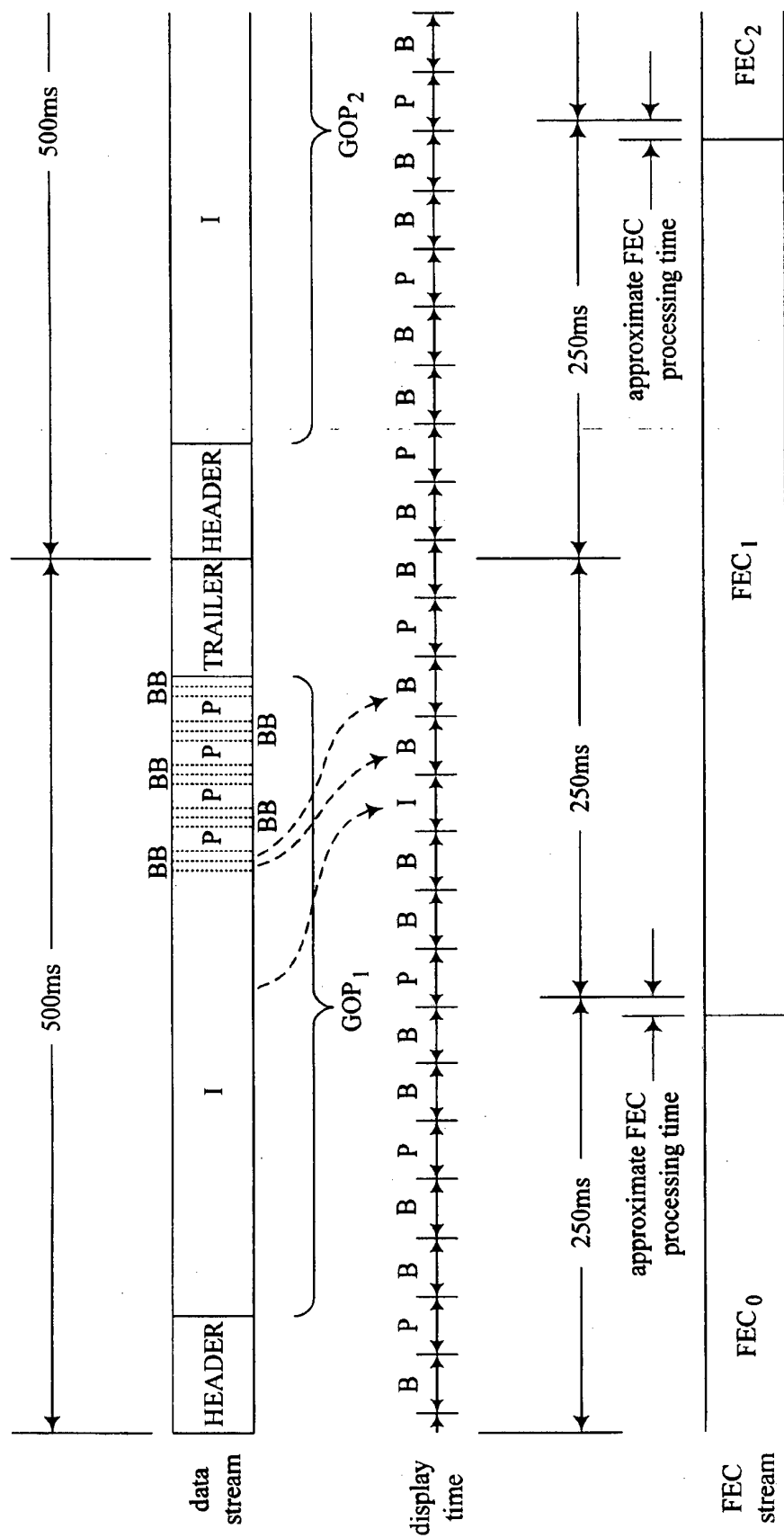


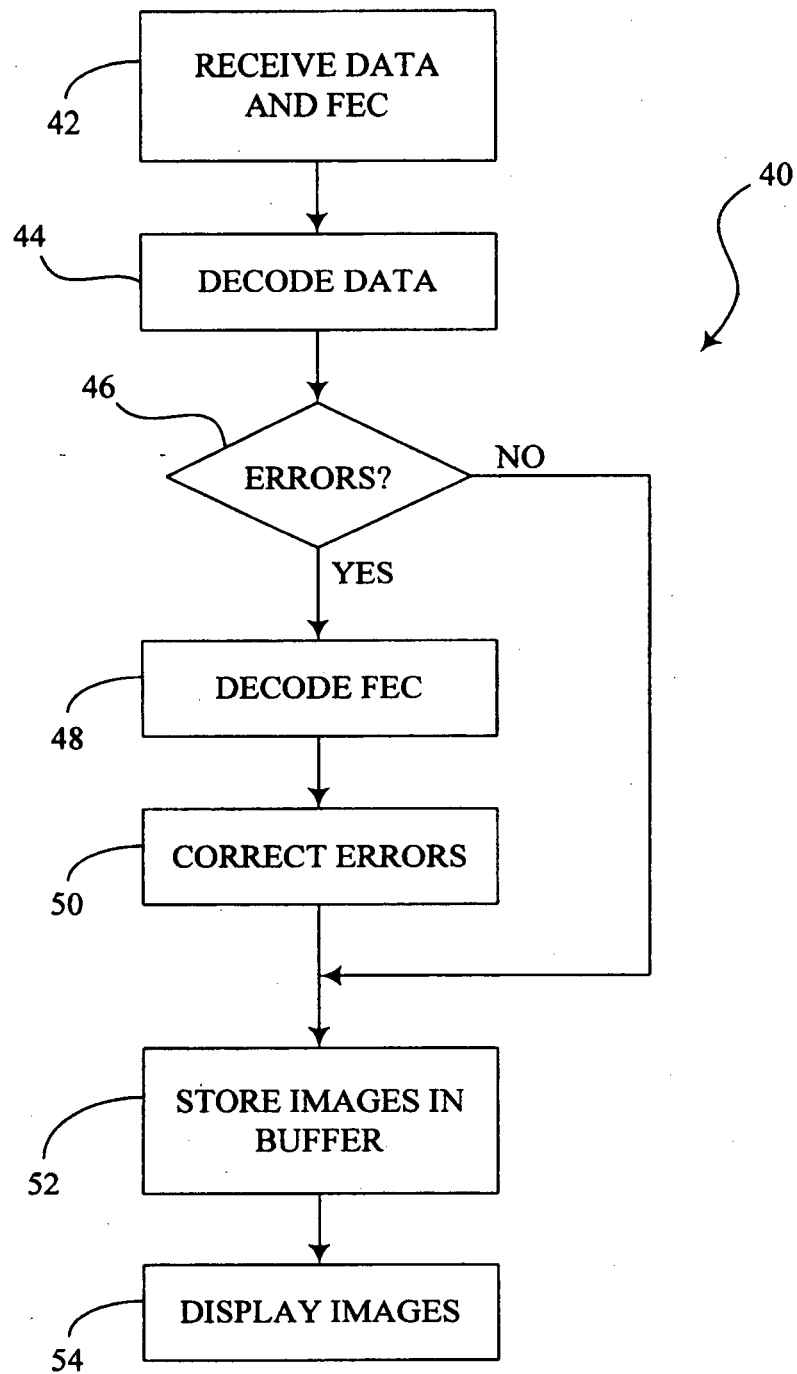
FIG. 2

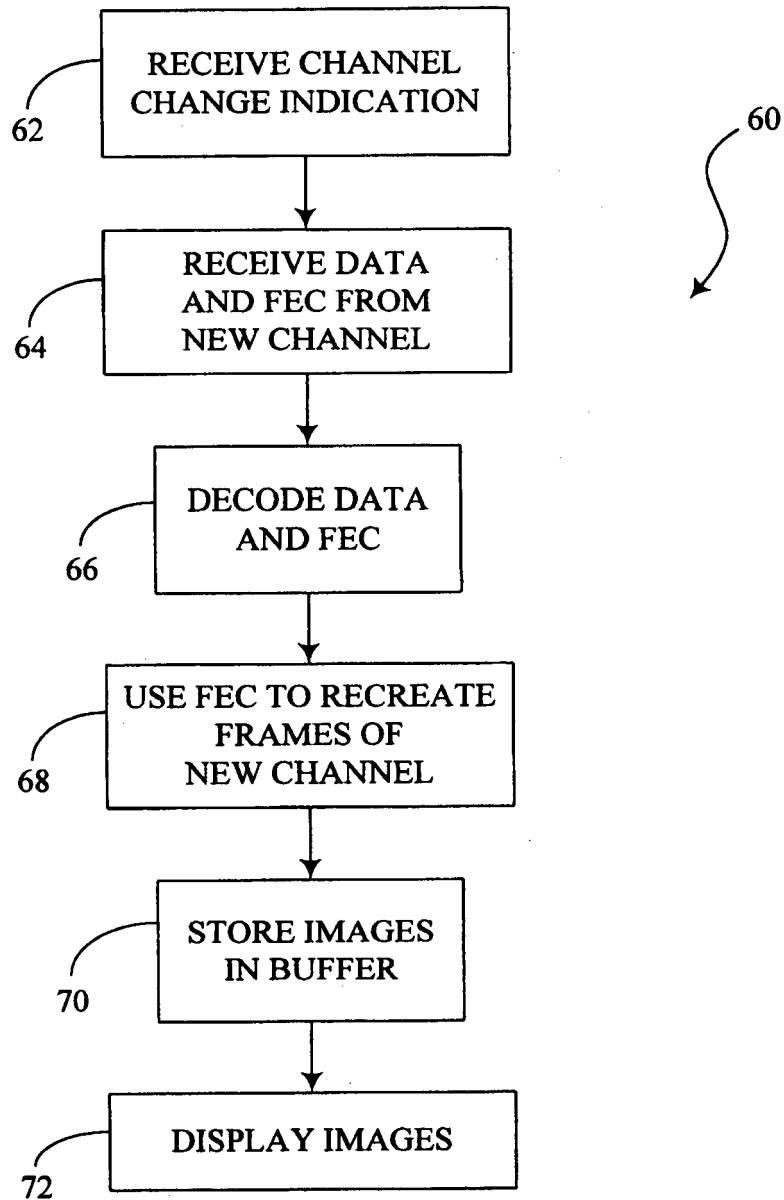
(0, 0)	(0, 1)	(0, 2)	(0, 3)	...	(0, C)	XOR ((0, 0) - (0, C))
(1, 0)	(1, 1)	(1, 2)	(1, 3)	...	(1, C)	XOR ((1, 0) - (1, C))
(2, 0)	(2, 1)	(2, 2)	(2, 3)	...	(2, C)	XOR ((2, 0) - (2, C))
(3, 0)	(3, 1)	(3, 2)	(3, 3)	...	(3, C)	XOR ((3, 0) - (3, C))
⋮	⋮	⋮	⋮	⋮	⋮	
(R, 0)	(R, 1)	(R, 2)	(R, 3)	...	(R, C)	XOR ((R, 0) - (R, C))

$\text{XOR}((0, 0) - (R, 0))$
 $\text{XOR}((0, 1) - (R, 1))$
 $\text{XOR}((0, 2) - (R, 2))$
 $\text{XOR}((0, 3) - (R, 3))$
 $\text{XOR}((0, C) - (R, C))$

FIG. 3**FIG. 4**



**FIG. 6**

**FIG. 7**

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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